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Well-dated fluvial sequences as templates for patterns of handaxe distribution: understanding the record of Acheulean activity in the Thames and its correlatives

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Abstract

The use of Acheulean (handaxe) typology as a cultural and temporal marker has been a topic of controversy in recent decades, with many archaeologists continuing to reject such an approach out of hand. Much of the controversy stems, however, from difficulties in reconciling the archaeological record from Quaternary sediments with a flawed and overly simplified chronostratigraphical template. With the adoption of the 'expanded chronology' based on the marine oxygen isotope record, underpinned by biostratigraphical and geochronological dating, has come the recognition of a meaningful progression of artefact types, such as the first appearance of Levallois technique, attributed to MIS 9–8 over widespread parts of the Old World. More recently it has been established that assemblages in Britain with twisted ovate handaxes in significant numbers represent MIS 11 occupation, while those with significant proportions of cleavers and 'ficron' handaxes appear to be correlated with deposits formed at around the time of the MIS 9 interglacial. The recognition of such patterns stems largely from the well-dated Thames sequence; it should not be confused with the previous use, in the mid-20th century, of archaeological typology as a crude dating indicator based on a relative refinement of tool making. Key means of age constraint for the Thames sequence have been mammalian assemblage zones representing the last four interglacial cycles, molluscan biostragraphy and amino acid racemization dating of molluscan material, especially the calcitic opercula of the gastropod *Bithynia tentaculata*, thus providing a framework within which the archaeological patterns can be identified.

1. Introduction

The typology and technology of stone tools have been used to order the archaeological record into chrono-cultural units since the infancy of Palaeolithic investigations in the mid-19th Century (e.g. Evans, 1862, 1872; Christy, 1865; de Mortillet, 1869, 1873,). In the Lower and

Middle Palaeolithic, it was the shape and technological sophistication of a single tool type, the handaxe, that usually formed the basis for division. Early groupings into meta-categories such as 'drift' and 'cave' implements included handaxes (e.g., Evans, 1872), but these were quickly replaced by subtler divisions, using diagnostic stone tools as 'fossile directeur' or marker fossils. The most influential and persistent scheme was that of Gabriel de Mortillet (e.g. 1869, 1873), who used the concept of stone-tool 'marker fossils' to divide the lithic record into chronological 'epochs', each named after a type-site where the stone tools in question were first discovered or were particularly well represented. The handaxe eventually came to define two epochs: the Acheulean (more refined handaxes) and the Chellean (cruder handaxes); at one point it was also considered a marker for the Mousterian (de Mortillet, 1869). As the complexity of the known record grew, these epochs became sub-divided into evolutionary stages, such as Commont's phases of the Acheulean (St Acheul I and Acheul 2: Commont, 1908), largely based on the refinement of handaxes over time, or Breuil's framework of multiple cultural 'phyla', each line evolving through a series of ever-more sophisticated tool forms that could be used to correlate the archaeological record with the Alpine glacial sequence (Breuil, 1932). Later still, these were replaced, in Britain and elsewhere, by a more compact division into early, middle and late Acheulean (e.g., Roe, 1968, 1981; Wymer, 1968).

Regrettably, some workers began using tool type and perceived level of refinement as the principal means for determining the age of an assemblage, often ignoring stratigraphical (un)feasibility in their interpretation (e.g. King and Oakley, 1936), which in the Thames Valley led only to confusion (cf. Bridgland, 1994). This situation persisted well into the 1970s and 80s, by which time British workers had started to correlate the Palaeolithic record with a largely palynologically-defined climate-stratigraphical framework (Mitchell et al., 1973; Roe, 1981). Ultimately, the pollen-based terrestrial framework recognized only two interglacials (and three glacials) over the course of the past 500,000 years, concealing evidence for twice that many full 100-ka Milankovitch cycles and numerous associated substages. With over half the available pieces missing and separate time periods often conflated into the same chronostratigraphical divisions, it is not surprising that patterns remained obscure, a problem that led many British workers to lose faith in the value of handaxes as chronological (and eventually also cultural) markers; John Wymer made a deliberate point of dismissing the notion in his last major synthesis of the British Pleistocene record to employ the older framework, although by this point he was beginning to realise that the complexity evident in the isotopic framework might help make more sense of the record (Wymer, 1988). Discoveries such as at Boxgrove, where lavishly refined ovate handaxes were found in early Middle Pleistocene (late Cromerian

Complex, Marine Oxygen Isotope Stage [MIS] 13 interglacial deposits beneath Anglian (MIS 12) slope deposits (making them among the oldest in Britain and ~50,000 years older than the supposedly cruder handaxes at Swanscombe and elsewhere) signalled the final death knell. For much of the next two decades, Palaeolithic workers in Britain and America moved their attention away from chronological or cultural explanations for variability within the Acheulean, and focussed instead on more 'processual' concerns, in which the key drivers were the influence of raw materials, function and resharpening (Ashton et al., 1992; McNabb, 1992; McPherron, 1994; White, 1998a).

Ironically, just as the Anglo-American archaeological world began to move away from traditional lines of enquiry, more-or-less synchronous developments in the wider fields of palaeoclimatology and Quaternary Science led to the emergence of an expanded chronological framework, in which the terrestrial record could potentially be convincingly correlated with the numbered marine oxygen isotope stages determined from studies of deep-ocean cores (Shackleton and Opdyke, 1973; Shackleton et al., 1990). Taking nothing away from the relevance of the behavioural, technological and theoretical explanations of stone-tool variation, this advance demonstrated that the 'compressed' framework was the major factor in Derek Roe's (1968, 1981) failure to organize his handaxe groups into discrete chronological periods, a problem he recognized explicitly. Although the terrestrial record is fragmentary by comparison, the adoption of an 'expanded' terrestrial chronology for the Middle Pleistocene allows the recognition of a meaningful sequence of artefact types that can be tied to patterns of climatic change and human dispersal (Bridgland, 1994, 2006; Pettitt and White, 2012; White, 2015).

This paper will build upon earlier work on this theme (Bridgland and White, 2014, 2015, White, 2015), with continued emphasis on the Thames and incorporating faunal and aminostratigraphical models to complement the stratigraphical data employed previously. The patterns revealed in stone-tool morphology will be discussed and a climatic model for understanding the key drivers behind the patterning will be examined, alongside evidence of faunal turnovers.

2. The fluvial context: the terrace sequence in the Middle and Lower Thames

The extensive literature on the Lower and Middle Palaeolithic of the Thames, and the central place of this valley in John Wymer's seminal reviews of the British archive (Wymer, 1968, 1999), serve to underline the primacy of this record as a template for understanding the hominin occupation of southern Britain during the Pleistocene. The excellence of this archive owes much to the rich sources of flint raw material in the Chalk outcrops of the Chilterns (Middle Thames) and Purfleet Anticline (Lower Thames). Here, prolific and occasionally primary-context sites generally coincide closely with the flint-bearing Chalk or extensive gravel deposits. The river-terrace record of the Thames has attracted much research over a century and a half, with the incremental establishment of a staircase of more than a dozen named terrace levels in the upper part of the Middle Thames, extending onto the Chiltern dip-slope and chronologically back into the Early Pleistocene (e.g., Hare, 1947; Hey, 1976; Gibbard, 1985; Bridgland, 1994; figure 1). Downstream from the Colne confluence, however, there are fewer terraces in the main Thames valley and none older than the Anglian (MIS 12). This is because the Thames was diverted into its modern valley through London by glaciation during the Anglian, prior to which it flowed further north, through Hertfordshire and into East Anglia (Gibbard, 1977, 1979; Bridgland, 1994), which is the route taken by the missing, older terraces. The post-Anglian sequence in the Lower Thames is, however, second to none as a climato-stratigraphical record of the last four Milankovitch (glacial–interglacial) climatic cycles and has been of considerable importance in establishing correlation between the NW European terrestrial and marine (MIS) sequences (Bridgland, 1994; Schreve, 2001a & b). This high quality is again largely thanks to the Chalk, which provides the calcareous substrate that has promoted the preservation of mammalian and molluscan fossils, both valuable indicators of palaeoclimate and of importance for biostratigraphy (Keen, 1990; Preece, 1995; Sutcliffe, 1964, 1995; Schreve, 2001a; Bridgland and Schreve, 2004; Schreve et al., 2007; White et al., 2013). As Figure 1 indicates, each terrace is formed by cold-climate lower and upper gravels, between which interglacial deposits are preserved at some locations, particularly near the valley-side edge. The most recent terraces fall beneath the floodplain and the floor of the estuary as the river approaches its mouth.

2.1 Underpinning by biostratigraphy

Bridgland (1994, 2000) proposed, on the basis of terrace lithostratigraphy, that the interglacial deposits within the four Lower Thames terraces (Fig. 1) represented the temperate components of the last four glacial–interglacial cycles, correlating with MIS 11, 9, 7 and 5(e). His claims (after, e.g., Castell, 1964; Sutcliffe, 1964, 1976; Allen, 1977) that there was support for this expanded climato-stratigraphy from palaeontology were subsequently tested, as indeed were the counter-claims for a ‘compressed chronology’ in the Lower Thames (e.g. Gibbard, 1994), by Schreve (2001a; Bridgland and Schreve, 2004).

Schreve's scheme of Mammal Assemblage-Zones (MAZs) within the post-Anglian sequence of the Lower Thames is depicted in Fig. 2. The scheme upholds the presence of interglacial deposits representing three late Middle Pleistocene interglacials (MIS 11, 9 and 7), prior to the Last Interglacial (MIS 5e), based on the recognition of discrete mammalian assemblage characteristics that typify each stage. The characteristics are drawn from the study of combined assemblages of tens of thousands of specimens, including presence/absence data, first and last appearance data and evidence of morphological change within key species or lineages. In addition, further complexity is recognised within MIS 7, with two MAZs identified, reflecting the early and late parts of this interglacial (Schreve, 2001a, b). Although the faunal complexity has been recognised for 15 years, it is interesting to note that the recent revision of the definition of Pleistocene interglacials by Berger et al. (2015) has now proposed two full interglacials of equal magnitude within MIS 7, referred to as MIS 7e and MIS 7a-c. This is consistent with the original observations made on the basis of the mammals, which were supported by absolute age-estimates (Candy and Schreve, 2007).

The value of molluscan faunas as a means for distinguishing between different palaeo-environments, climates and ages had been well established in early research in the Thames, notably by A.S. Kennard (e.g., 1924, 1942; Kennard and Woodward, 1897, 1900), and was enhanced in more recent years by the work of Keen (1990, 2001) and Preece (1995, 1999). A landmark contribution from the mid 20th Century was by Kerney (1971), who used the molluscan record from Swanscombe to correlate between that site, which lacked a palynological record, and the laterally equivalent fluviatile–estuarine sequence at Clacton, which had provided the first interglacial pollen diagram (cf. Pike and Godwin, 1953). Kerney's work, which has stood the test of time remarkably well, was augmented recently by White et al. (2013), who used ostracods in addition to molluscs in order to clarify the climatic and sea-level evolution of the Hoxnian interglacial in the lowermost part of the Thames system.

2.2 Underpinning by amino acid racemization dating

Fossil molluscan remains have provided raw material for an innovative dating technique based on post-mortem protein degradation in shell, applied in pioneering studies in NW Europe from the late 1970s onwards (Andrews et al., 1979; Miller et al., 1979; Miller and Mangerud, 1985; Bowen et al., 1989). The results on thin-shelled gastropods included a very small number of problematic outliers (e.g. Bowen et al., 1995), but it became apparent that the progressive degradation of intra-crystalline amino acids was considerably more orderly and predictable

(Sykes et al., 1995; Penkman et al., 2007). The quality of the intra-crystalline protein in calcitic opercula of the gastropod genus *Bithynia* (rather than aragonitic mollusc shells) has allowed a significant volume of data to be accumulated from deposits with calcareous fossils in the Thames and nearby systems (Penkman et al., 2007, 2011, 2013), providing further support for the age-model established from the Lower Thames sequence by Bridgland (1994; Fig. 3). Although data from adjacent interglacials often plot in close proximity (or even show overlapping distribution), due to the low levels of racemization in cold-stages, the use of a number of amino acids that racemize at different rates enhances the resolution of the technique.

3. The Palaeolithic record from the Thames

The Thames Valley contains the richest concentration of Palaeolithic archaeology in Britain, numbering thousands of find spots and hundreds of thousands of artefacts. Arguably this begins with the oldest of Britain's Palaeolithic assemblages, that from Happisburgh 3, which has been associated with an Early Pleistocene extended Thames (Parfitt et al., 2010; cf. Hey, 1980). If the alternative younger (early Middle Pleistocene) age for this assemblage suggested by Westaway (2011) were to be proved correct, however, its Thames credentials would be thrown into doubt, as the northern part of East Anglia in which the site is located was in the Bytham catchment by that time (Rose et al., 2001; Lee et al., 2004; Bridgland, 2010; cf. Bridgland, 1994, Westaway et al., 2002).

The early Middle Pleistocene 'Cromerian Complex' is not well represented in the Thames, largely because of the disruption caused to the river system by the diversion by Anglian (MIS 12) ice. Thus there was no Lower Thames through London until this event took place, which means that the sequence in the (archaeologically) most prolific reach begins at the Anglian. It is no surprise, then, that the best candidate for the earliest archaeology in the Thames valley is in the Middle Thames: the ovate handaxe assemblage found at different localities along the 'Ancient (Caversham) Channel' in Berkshire (Wymer, 1961, 1968, 1988). Given that the gravel flooring this abandoned section of valley is ascribed to the Black Park terrace (formed in the late Anglian when the river was newly diverted but ice still blocked its former course to the north of London (Gibbard, 1979; Bridgland, 1994)), this assemblage is presumably an accumulation of material derived from a late Cromerian (MIS13) landscape or, rather less probably, evidence of occupation during an MIS 12 interstadial (Wymer 1968, 1988, 1999).

The first well-established human occupation in the Thames valley did not occur until the end of the Anglian, where it is well documented by artefacts found in the Boyn Hill/Orsett Heath Terrace (MIS 11) at the Barnfield Pit, Swanscombe, Kent, and lateral equivalents (see Bridgland 1994; Conway et al., 1996; Wenban-Smith and Bridgland, 2001; White et al., 2013). Once considered the type-site for the British Lower Palaeolithic (McNabb, 1996), the cultural sequence at Swanscombe commences with a non-handaxe or Mode 1 assemblage internationally known as the Clactonian (see White, 2000), found in both the principal 'Phase 1' divisions of the sequence, the Lower Gravel and the Lower Loam (Smith and Dewey, 1913; Bridgland, 1994; Conway et al., 1996). The same industry is found in the lateral equivalents of the Barnfield Phase 1 deposits at Rickson's Pit, Swanscombe (Dewey, 1932; Wymer, 1968; Roe, 1981; Bridgland, 1994), and at the Clactonian type locality ~90 km to the NE, at Clacton-on-Sea (Warren, 1926; Bridgland, 1994; Bridgland et al., 1999).

Handaxes first appear in the Swanscombe sequence in the (Phase 2) Middle Gravels, in which they are usually small and pointed in form. This cultural transition is thought to correspond broadly with the end of pollen zone HoIIb, presumably during part of MIS 11c (see Ashton et al., 2008; Pettitt and White, 2012). Later within the sequence, twisted ovate handaxes have been recorded from the Upper Loam (Phase 3) at Barnfield Pit (Roe, 1968, 1981) as well as in the laterally equivalent 'Wansunt Loam' in Wansunt and Bowman's Lodge pits, Dartford Heath (Tester, 1951, 1975; White et al., 1995; Wenban-Smith and Bridgland, 2001). In a British context, assemblages dominated by such handaxes appear to be concentrated in this late MIS 11 timeframe (White, 1998b). Recently, White et al. (2013) have suggested that the further occurrence of an assemblage rich in twisted ovates at Dierden's Pit, Ingress Vale (Smith and Dewey 1913), 0.5 km to the NW of the primary Swanscombe locality (the Swanscombe Skull Site National Nature Reserve), dates from MIS 11a, in concord with others from north Kent. Outside the Thames Valley representatives of this distinctive assemblage type, with a notable twisted-ovate content, include those from Elveden, Suffolk (Ashton et al., 2005), and Foxhall Road, Ipswich (White and Plunkett, 2004).

Following the MIS 10 glacial, humans returned to NW Europe as conditions began to ameliorate at the transition into MIS 9. The next terrace in the Thames sequence, the Lynch Hill/Corbets Tey (MIS 10–9–8), incorporates some of the richest sites in the country. Although the dating is dependent on the fossiliferous sites of the Lower Thames (Schreve, 2001a; Bridgland and Schreve, 2004), the Lynch Hill terrace of the Middle Thames boasts over 192 sites and findspots, with some 'supersites' such as Furze Platt yielding thousands of artefacts (Wymer, 1968, 1988, 1999; Cranshaw, 1983; Bridgland, 1994). The equivalent terraces of the Solent also contain large numbers of artefacts (Hosfield, 1999; Westaway et al., 2006; Ashton and Hosfield, 2009). That said, the relative paucity of flagship sites and the relatively recent recognition of MIS 9 within the terrestrial record mean that the settlement history of that period is only now coming into focus, a keystone development being the evidence from Purfleet (Schreve et al., 2002; Bridgland et al., 2013). Within an abandoned valley loop at the Corbets Tey terrace level preserved on the northern side of the Thames in Essex, the thick, well-studied sequence of deposits at Purfleet has yielded three distinct archaeological industries in stratigraphical superposition. At Greenlands and Bluelands pits, Purfleet, the basal chalky solifluction deposits and overlying temperate-climate Little Thurrock Gravel contain a non-handaxe (Mode 1) assemblage comprising hard-hammer flakes and cores. These are capped by shelly beds and estuarine silts and clays that have yielded isolated flakes, above which lies the Bluelands Gravel, containing an Acheulean assemblage with sparse handaxes. At Botany Pit, Purfleet, a continuation of the main sequence shows a transition between the Acheulean and an early Middle Palaeolithic assemblage revealing use of a 'proto-Levallois technique' (Wymer, 1985; White and Ashton, 2003). Some classic Levallois material is present at Botany Pit, although there appears to be no recorded stratigraphical separation between this and the proto-Levallois occurrence (Andrew J. Snelling personal communication). However, Levallois material is also present in the equivalent Botany Gravels at the Greenlands and Bluelands (Armor Road) sites (see Bridgland et al., 2013). This earliest appearance of the Levallois knapping technique within the Thames may be attributed to either the MIS 9–8 transition or even the terminal parts of MIS 9 (see Schreve et al., 2002; Westaway et al., 2006; Bridgland et al., 2013).

The archaeological sequence at Purfleet reflects regional patterns of cultural change in Britain through the MIS 10–9–8 climate cycle. Other non-handaxe/Mode 1 assemblages belonging to the late MIS 10/early MIS 9 Little Thurrock Gravel are found at Globe Pit (Bridgland and Harding, 1993) and in potentially equivalent deposits at Cuxton in the Medway valley (Cruse, 1987; Bridgland and White, 2015); at the latter it occurs beneath an Acheulean assemblage containing abundant ficron and cleaver type handaxes. While the Mode 1–Mode 2 transition is yet to be more widely validated, the same combination of handaxe types is found at other archaeological sites in the Lynch Hill/Corbets Tey Formation, most notably at Furze Platt and Baker's Farm in the Middle Thames and Stoke Newington in North London (Roe 1968; Wymer 1968, 1988; Bridgland and White, 2014).

Other Levallois assemblages have been recovered from gravels and brickearths within and on top of the Lynch Hill Terrace at Creffield Road, Acton (west London), and a series of pits at Yiewsley and West Drayton, in the Middle Thames (Ashton et al., 2003; Scott, 2010). Levallois assemblages dominate the archaeological record of Britain within the Taplow/Mucking Terrace (MIS 8–7–6; see White et al 2006), with notable examples at Northfleet (Burchell, 1933, 1936; Bridgland, 1994), West Thurrock (Schreve et al., 2006) and Crayford (Kennard, 1944) in the Lower Thames. A mint-condition Levallois core from Stanton Harcourt, Oxfordshire, also suggests the presence of Levallois-equipped groups in the upper reaches of the river during this same climatic cycle (Buckingham et al., 1996).

Following a brief burst of Levallois activity seen in the Thames record from early in MIS 7, evidence of human presence is generally sparse for the rest of the interglacial. Small assemblages testifying to human presence in later MIS 7 occur in the Upper Sands at Aveley in the Lower Thames (Schreve, 2004), and outside the Thames Valley they might also be represented at Selsey, West Sussex, and at Stoke Tunnel and Brundon, Suffolk, although according to AAR Selsey belongs to the earliest part of MIS7. The large Levallois assemblage from Crayford (Spurrell, 1880; Kennard, 1944), associated with a complex fauna that gives a mixed climatic signature (Scott, 2010), might also belong in late MIS 7, perhaps MIS 7b–7a, or an early MIS 6 interstadial (Pettitt and White, 2012). Following MIS 7 there is no evidence of any human occupation in Britain until the start of MIS 3, when recolonization took place, by Neanderthals associated with a Mousterian of Acheulean Tradition assemblage that included the bout coupé type handaxe, arguably a marker-fossil for MIS 3 in Britain (White and Jacobi, 2002).

3.1. Temporal variation within the Acheulean

The Lower Palaeolithic settlement history of Britain presented above (cf. Figure 4) has been developed piecemeal over several decades using a variety of independent evidence, although it will not satisfy everyone (e.g. McNabb 2007; Bates et al 2016). There is also little agreement regarding the anthropological meaning of any apparent patterning, and archaeologists have been slow in examining whether smaller-scale variations exist in the record. The latter is largely a consequence of the dominant research agendas favouring other aspects of behaviour and a stubborn new orthodoxy that denies the existence of such variations or, if they are recognized, considers them to have no meaningful patterning in time or space.

This position is in need of revision (Bridgland and White, 2014, 2015; White, 2015). Viewed from the scale of Derek Roe's (1968) seven sub-groups, rather than his higher tier of pointed and ovate 'traditions', there is a clear correlation between modal shape and the age of an assemblage, excluding those sites for which no firm dating evidence exists (Table 1). Certain specific forms, such as ficrons, cleavers, twisted ovates and bout coupé handaxes, also appear to cluster according to age.

All British pre-Anglian handaxe assemblages fall into one or other of Roe's Groups V and VII. Although sometimes described as belonging to an Early Acheulean (Roe, 1968), the age of those assemblages assigned to Group V (from, e.g., Kent's Cavern, Fordwich, Farnham) is unclear, and they may span MIS 15–13 (Bridgland et al., 1998; Lundberg and McFarland, 2007). The influence of raw material shape rather than technological incompetence among early colonisers may partly explain the crude character of the handaxes in this group (White, 1998a). The first securely-dated handaxes occur in late MIS 13 contexts, at sites such as Boxgrove, Waverley Wood and Warren Hill (Wymer, 1985; Roberts and Parfitt, 1999; Keen et al., 2006; Hardaker, 2012), which fall exclusively into Roe's Group VII.

The fresh handaxes from Highlands Farm in the Ancient (Caversham) Channel, which have morphological affinities with the Boxgrove material (both belong in Roe's Group VII), are accompanied by more rolled material from the Black Park Terrace in general, and especially its lateral upstream continuation as the Silchester Gravel of the Kennet. In the latter deposit Roe (1981) noted that the abraded handaxes are typically of the 'crude' typology that characterizes his Group V, whereas the accompanying fresher material shows a higher refinement of knapping style. Unaware at that time of the of the Boxgrove assemblage and its pre-Anglian credentials, Roe saw this fresher archaeology as intrusive post-Anglian artefacts incorporated in top of the Silchester Gravel, a similar interpretation to that put forward for the comparable finds from the Black Park Terrace of the Middle Thames (cf. Wymer, 1961). From a modern understanding it is possible to point to the consistent pattern in these (late) Anglian gravels of the Thames and the identical co-occurrence of rolled Group V and fresh Group VII handaxes in the Anglian gravels of the Bytham at Warren Hill, Mildenhall (Roe, 1968; Rose, 1987; Wymer, 1985, 1999; Hardaker, 2012). There is a strong hint that the Group V assemblages reflect an occupation from deeper in the pre-Anglian.

Human occupation in the Hoxnian (MIS 11) interglacial began with a Clactonian industry, which lasted until late in the early temperate substage (~HoIIb), when handaxes appeared. Two expressions of the Acheulean are found in MIS 11 deposits, the point-dominated Group II and the ovate-dominated Group VI, with no obvious chronological pattern or sequence. For example, at Swanscombe, a point-dominated assemblage occurs below an ovate-dominated assemblage, yet the opposite occurs at Foxhall Road and at Hoxne. This, and the fact that well-made ovates also occur in Group II assemblages (most notably from Hitchen, Dovercourt and the Red Gravel at Foxhall Road) suggests that, at a higher scale, the form of the raw materials found in different landscape contexts may have influenced the basic shape dominance at a site, with hominins choosing a suitable target form from a shared but flexible knapping repertoire (White, 1998a). That said, most of the Group VI sites (and Hitchin from Group II) contain high proportions of twisted ovate handaxes, whereas Group II sites show the highest proportions of twisted tips (Roe, 1968; White, 1998b). Recent work at Hoxne (Ashton et al., 2008) suggests that contexts yielding high percentages of twisted ovate handaxes might belong to MIS 11a, as has also been suggested for the Swanscombe 'Phase 3' occurrences of such implements (White et al., 2013; see above).

Dated handaxe assemblages belonging to Group I are all from deposits belonging to the MIS 10–9–8 Lynch Hill/Corbets Tey terrace of the Thames or from contemporaneous contexts in other rivers. These assemblages are characterized by a marked frequency of ficron and cleaver handaxe types; the latter form was argued by White (2006) to have resulted from the re-sharpening of ovate handaxes, a particular technological practice employing both tranchet and non-tranchet removals that was widely used at this time.

As noted above, the MIS 8–9 transition saw the appearance of Levallois in the British Palaeolithic, following which the Acheulean handaxe disappeared. Although strictly speaking not an Acheulean occurrence, handaxes eventually reappeared in Britain during MIS 3 as part of a 'Mousterian of Acheulean Tradition' tool-kit. This marks the first settlement of Britain since the end of MIS 7, with humans apparently completely absent throughout the 100,000 years encompassing MIS 6, 5 and 4 (Ashton 2002; Lewis et al 2011). Among the handaxe types made by these Neanderthal immigrants was a form considered more-or-less peculiar to MIS 3 Britain: the so-called bout coupé (White and Jacobi, 2002). The sparse record and small exhausted tool-kits suggest that this period saw only brief episodic visits, perhaps seasonally. The final assemblage associated with Neanderthals belongs to the 'transitional' industry termed the Lincombian–Ranisian–Jerzmanovician (LRJ: Pettitt and White, 2012; cf. Jacobi, 2007); it has been dated to ~44 ka. Like the bout coupé, LRJ assemblages provide a useful marker for the British Early Upper Palaeolithic if used with due caution and attention to context.

3.2: Europe: Is Britain IN or OUT?

The temporal patterns highlighted above are neither linear nor predictable. At the available resolution, there is no evidence for the gradual replacement of one form by another, or an evolution from less- to more-sophisticated bifacial working techniques or products over time. Rather, one accomplished Acheulean expression is replaced by another equally accomplished expression during different Milankovitch cycles.

White (2015) explained this pattern in terms of the ebb and flow of different hominin populations during the course of the Middle Pleistocene, in response to the palaeogeographical effects of climate change and sea-level fluctuations on the British landscape (Figure 7). Based on five separate sea-level reconstructions, White (2015) concluded that, whereas Britain was certainly connected to Europe during full cold stages and possibly cold sub-stages, it had experienced isolation from Europe for parts of each post-Anglian interglacial. He also assumed that existing populations experienced local extirpation during glacial maxima.

The model depicted in Table 2 suggests that Pleistocene hominins in Britain lived under conditions that rarely allowed stable long-term adaptations, a pattern also true of much of Europe (Dennell et al., 2010). The Pleistocene peopling of Britain (and Europe) was instead characterized by patterns of 'expansion and contraction, abandonment and re-colonization, integration and isolation' (Dennell et al., 2010, p. 1514). Dispersal was the rule, and settlement was infrequent and intermittent. Its geographical position and cyclical island status meant Britain was probably a human wasteland for >50% of Middle Pleistocene time, interspersed with periods of colonization and relatively brief pulses during which humans were resident in Britain. During glacial maxima, the population of Europe probably contracted into a few southern refugia such as the Iberian and Italian peninsulas and the Balkans and/or western Asia (Dennell et al., 2010). Such refugia preserved source populations for recolonization, although the record is too partial to determine whether even these areas were continuously occupied; different refugia may have operated at different times, according to the intensity and local effects of climatic cycles and evolving survivorship skills.

This means that stable or predictable patterns in stone-tool typology and technology would never have existed in Britain and should not be expected. With each cycle, Britain formed a 'sink' area that required populating by people originating from elsewhere; even during periods of occupation, populations may have been reproducing below replacement levels and thus continuously topped-up from outside, should sea levels make this this possible. Each new occupation brought with it new archaeological signatures, the character of which depended on the type of industry prevalent within the source populations (which may have been from more than one refugium) and its expression on the eve of colonization, after several thousand years of population expansion/dispersal and cultural selection/drift etc. Proximal correlatives for the British Acheulean may potentially be identified among our nearest European neighbours, and endemic transformations to pre-existing structures may have occurred during periods of geographical or social isolation. Extending the social network geographically and isolating the input of a particular refugium may never be possible, however. The coarseness of our temporal resolution, a limited understanding of regional and sub-regional cultural geographies, a lack of pan-continental databases to aid correlation, and the probability of coincidental convergence of tool-form in two unrelated assemblages are all major obstacles to overcome. Interrogation must therefore always be articulated and addressed at the appropriate scale.

3.2: Faunal Correlations

The majority of Levallois assemblages in Britain occur in sediments attributed to MIS 8–7. Within the interglacial proper, examples are found associated with both the Ponds Farm and Sandy Lane MAZs. While the Ponds Farm MAZ (MIS 7e?) is characterised by temperate-climate, woodland taxa such as straight-tusked elephant (*Palaeoloxodon antiquus*), the Sandy Lane MAZ (MIS 7a?) is defined by a suite of taxa indicative of warm, open grassland with reduced forest cover (Schreve, 2001b). In terms of biostratigraphically significant taxa, water voles (*Arvicola terrestris cantiana*) from MIS 7 are represented by an intermediate morphotype in terms of enamel differentiation on the molars (see Schreve, 2001a for details) and the combination of a late form of steppe mammoth (*Mammuthus trogontherii*) with horse (*Equus ferus*) is considered particularly diagnostic for the Sandy Lane MAZ.

Bout coupé handaxes, and the entire Late Middle Palaeolithic, are associated with the Pin Hole MAZ (Currant and Jacobi, 2011). Radiocarbon dating of key elements of this faunal grouping affirm correlation with MIS 3, key members including woolly mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), horse (*Equus ferus*) and spotted hyaena (*Crocuta crocuta*). No taxa are alone specifically diagnostic of this period but in combination, they make up a characteristic faunal grouping that indicates the middle part of the last glacial, c.60–25ka

3.3: Considerations of palaeogeography

Following the breach of the Weald–Artois anticline and the initiation of the Strait of Dover at the end of MIS 12, conditions existed for Britain to become an island during every warm period with sufficiently high sea levels. Evidence for the onset of brackish conditions in interglacial sequences in the Lower Thames and other fluvial systems has been recognized as a useful indicator of Britain's fluctuating island or peninsula status and the possibility of human and mammal immigration (e.g. White and Schreve, 2000). At Swanscombe, brackish indicators have been reported from the Barnfield Pit sequence, in the form of a vertebra of Bottlenose dolphin, *Tursiops truncatus* (Sutcliffe, 1964), occasional shells of hydrobiid molluscs (Kerney, 1971) and otoliths of European Smelt, *Osmerus eperlanus* (Stinton, 1985), although none of this evidence could be accurately correlated with the Hoxnian pollen record. The occurrence of noded valves of the ostracod *Cyprideis torosa* in the Dierden's Pit sequence provided the first index point for both the onset and strength of brackish conditions at Swanscombe, appearing within pollen zone Ho IIIa and indicating relatively low salinities (White, 2012; White et al., 2013). Importantly, this evidence appears during the phase of colonization by the 'Rhenish' suite of molluscs, which has underpinned suggestions that the Thames was confluent with continental rivers for several decades (Kennard, 1942; Kerney, 1971; White et al., 2013). Similar records have been recovered from East Hyde, Tillingham (Roe, 2001; White, 2012) and Clacton-on-Sea (White 2012, suggesting that a single episode of sea-level rise affected the Lower Thames during a relatively late phase of the Hoxnian Interglacial (White et al., 2013, in prep.; cf. Schreve, 2001b; White and Schreve, 2000).

The emerging complexity of the British terrestrial record, particularly for MIS 11 (Ashton et al., 2008; White et al., 2013; Candy et al., 2014) provides a further basis for biogeographical hypotheses. The Swanscombe MAZ is defined on the basis of a distinct suite of species found at Swanscombe, Clacton-on-Sea and Hoxne (Schreve, 2001a, b); the assemblages from Swanscombe and Clacton can be confidently attributed to the Hoxnian/MIS 11c, but the archaeological assemblages and associated fauna from Hoxne were predominantly recovered from a later part of the sequence now attributed to MIS 11a (Ashton et al., 2008). It is therefore possible that the suite of mammal species (including handaxe-producing hominins) that constitute the Swanscombe MAZ colonized Britain on two occasions during MIS 11, with a probable hiatus during the cold substage MIS 11b, represented by the 'Arctic Bed' at Hoxne (Ashton et al., 2008). This scenario is supported by the evidence for relatively late sea-level rise during MIS 11c (White et al., 2013), a trend presumably slowed or even reversed during the cold climatic conditions of MIS 11b and prolonging connection between Britain and continental Europe. This could have provided the opportunity for a second colonisation of Britain following MIS 11b, or hominins could have survived in small numbers (in refugia) on the British landmass.

Data from the three Hoxnian Lower Thame-eastern Essex localities (Swanscombe, East Hyde and Clacton) provide a remarkably consistent record of the onset of estuarine conditions during pollen zone Ho III of MIS 11c (White, 2012; White et al., 2013). Sedimentary sequences representing subsequent late Middle Pleistocene interglacials are less well preserved and represent much shorter periods of time, so that discerning the precise onset of estuarine conditions relative to pollen records is more difficult. Evidence for brackish conditions in the Lower Thames during MIS 9, for example, first occurs somewhat earlier, in association with pollen signatures attributed to substage II (e.g. Bridgland et al., 2001, 2013; Green et al., 2006); it should be noted, however, that because the earliest substages of the MIS 9 interglacial are poorly represented in the Thames sequences a clear transition from freshwater to brackish conditions during that interglacial has not yet been documented. During MIS 5e, best represented by sequences preserved at Trafalgar Square (Preece, 1999), brackish fossils have been documented in association with pollen attributed to the early temperate substage of the interglacial, although the precise timing of the onset of estuarine conditions is again unclear. Nevertheless, the Lower Thames record provides a valuable overview of Britain's increasingly isolated status during late Middle and Late Pleistocene interglacials, suggesting that the window of opportunity to colonize Britain became progressively narrower in successive highstand episodes.

4. Discussion

As shown in Table 1 and discussed above, the chronological patterning in stone tool industries extends beyond the Thames, although the record there is by far the richest. In East Anglia, early Hoxnian Mode 1 technology gives way to a Mode 2 Acheulean at Barnham, where recent fieldwork has demonstrated that the two are indeed two separate assemblages (Ashton et al 2016, revising Ashton et al., 1998). To date no convincing example of an early MIS 9 Mode 1 occurrence has been found outside of the Thames Valley, possibly due to problems of admixture with Acheulean handaxes through collection bias or taphonomic processes.

Acheulean assemblages are a feature of every interglacial from MIS 13 to MIS 9, with the patterns detected in the Thames Valley apparently valid for the entire country. In the Solent, twisted-ovate handaxes have been recovered from the Old Milton Gravel at Barton on Sea (Evans, 1872), correlated with MIS 11–10 (Westaway et al., 2006), and examples of the same age are found at Elveden and Foxhall Road in Suffolk (White, 1998b). Similarly, the site of Warsash in the Solent, recently argued to date to MIS 9 (Davis et al., 2016), has ficrons and cleavers, as does Cuxton in the Medway Valley (Wenban-Smith, 2006). Unfortunately, the best-known sites in East Anglia with large numbers of ficrons and cleavers, such as Whitlingham and Keswick, Norfolk, are unsatisfactorily dated, although the presence of Levallois at Keswick might be taken to imply an MIS9/8 age (see below). Resolving the age of these sites would do much to test the correlation between Roe's Group I and MIS 9.

The emergence of Levallois in MIS 9–8 occurs at a national level, with densities falling off towards the west (Table X). Recent work (Ashton and Hosfield, 2009; Bates et al., 2014;) has suggested a late persistence of the Acheulean in western Britain, although the ages assigned to the two sites driving this hypothesis - Harnham and Broom - are disputable. We suspect that Harnham the MIS8 date for Harnham is a result of mass displacement, with MIS 9 artefacts moved wholesale from their original resting spot and incorporated into a younger solifluction layer; largely preserving their original technological integrity but resetting the geometric clock of their context and incorporating younger faunal elements. This taphonomic process was recently reported at Westcliffe St Margarets, Kent, where Lower Palaeolithic handaxes, cores and débitage (some of which conjoined) that are unquestionably 300 ka or earlier in their typology and technology were recovered from a slope deposit dated by OSL to 140-80 ka (Bailiff et al. 2013). OSL dates on the chert handaxe-bearing Wadbrook Member at Broom range between 324 ka and 282 ka (Hosfield and Green 2014). Given that this spans the MIS 9-8 boundary and has 'post-temperate' environmental indications, it has been postulated that Broom may represent another late persistence of handaxes at a time when the rest of Britain was adopting Levallois technology (i.e MIS8). However, this 42,000-year bracket also spans several substages of MIS 9, making the precise warm-cool phase transition very difficult to pinpoint. Archaeologically, Broom is dominated by ovate and cordiform handaxes, a number of which display a marked shape asymmetry, but also contains significant numbers of cleavers as well as ficrons and Wolvercote-type planforms. While there is nothing to rule out such a late persistence, we suggest a more parsimonious explanation is that the archaeology at both sites belongs to MIS 9, prior to the appearance of Levallois.

By MIS 7, Levallois technology had supplanted handaxes almost entirely, with important Levallois sites of this age outside the Thames including Brundon and Stoke Tunnel, Suffolk and Selsey in West Sussex (White et al., 2006). As for the earlier period, Levallois is generally rarer in the west, although the cave site of Pontnewydd in the Elwy Valley of northwest Wales, demonstrates that humans were present there for prolonged periods of time (Aldhouse-Green et al., 2012). An important faunal turnover occurred during MIS 7 (Schreve 2001b, Candy and Schreve, 2007), separating MIS7 e (the Sandy Lane MAZ) from MIS 7a–c (the Ponds Farm MAZ) (Schreve, 2001b; in press). That artefacts are found associated with both MAZs demonstrates that humans were present during both interglacial substages, although probably in vanishingly small numbers. Table 1 provides a list of sites and sequences dated to this period, showing a clear pattern of Acheulean giving way to Levallois within this terrace formation. This is unlikely to be the result of MIS 7 Levallois activity discarded on the top of MIS 9 terrace deposits and incorporated into contemporary or later brickearth deposits, as one would reasonable expect to see equal amounts of Levallois technology across all older terrace levels. This is not the case, although it is often true of Mousterian handaxes.

Another fauna–artefact correlation is found with the Pin Hole MAZ and bout coupé handaxes (White and Jacobi, 2002), both of which mark the MIS 3 Middle Palaeolithic occupation of Britain. From the distribution of this distinctive handaxe type it is clear that Neanderthals were active across all of southern Britain, probably in small numbers judging by the number of find spots and small assemblages left in caves. Again there is a paucity of evidence in the south-west beyond Somerset, although Coygan Cave in Carmarthenshire, Wales, demonstrates that there was human presence in the far west.

The next step will be to look towards Europe, to determine whether similar patterns can be detected, or whether Britain, by virtue of its fluctuating geographical status, provides a unique laboratory. As a sink region, the British Isles received a fresh cultural input with each new wave of humans, which during periods of isolation (physical or social) may have led to short-lived endemic developments. If patterns can be established in Europe, these might be usable to trace population movements over time, albeit that the record might be too fragmentary and the patterns obscured.

6. Conclusions

Well-dated fluvial sequences can provide valuable templates for understanding the evolution of Quaternary faunas and human occupation and activity, as has been exemplified by the river terrace record from the Thames in particular. In the Thames, and especially in its lower reach east of central London, there is a very clear age-model for the sequence, provided by mammalian and molluscan biostratigraphy and by amino acid geochronology from mollusc shells. For the latter, the best data come from the calcite opercula of the gastropod genus *Bithynia*.

With the establishment of this well-constrained terrestrial record it has proved possible to recognize clear patterns of differences between Acheulean handaxe assemblages, broadly confirming the chronological significance of the handaxe groups recognized by Derek Roe, albeit with refinements. Thus, the climatic cycles incorporating the MIS 13, 11 and 9 interglacials are characterized, respectively, by (1) assemblages of Boxgrove-type refined ovate handaxes, (2) pointed and ovate handaxes, the latter often twisted, and (3) cleavers and ficron-type handaxes. Handaxes and the Acheulean were largely supplanted by the appearance, at or just before the MIS 9–8 transition, of Levallois technology, although the former returned, within the Mousterian of Acheulean Tradition, in the form of the bout coupé.

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FIGURE CAPTIONS

Figure. 1 – Location map showing places and river systems discussed in the text in southern and midland England. An inset shows the sites in the Lower Thames.

Figure 2: a) The Middle Thames terrace staircase. The stratigraphical location of assemblages with Derek Roe's handaxe groups is indicated (for explanation, see text). Modified from Bridgland and White (2015); b) The Lower Thames terrace sequence. Handaxe assemblages that can be assigned to Roe's (1968) groups are indicated. Modified from Bridgland and White (2015)

Figure 3: Idealized transverse section through the Thames terrace staircase with features of the Mammalian Assemblage-Zones (MAZ), archaeology and correlation with the marine oxygen isotope record indicated (modified from Schreve 2001a).

Figure 4: The value of AAR data from *Bithynia tentacula* opercula as a dating aid. A - Idealized transverse section through the Lower Thames terrace sequence (after Bridgland, 2006), reversed from Figs 2 & 3 (to match B). B - Plots of THAA (hydrolysable amino acid fraction) vs FAA (free amino acids) D/L Ala from Thames sites. These two measures provide a relative aminostratigraphic template, where young samples fall towards the bottom left and old samples lie towards the top right of the graph. Note the concordance of relative terrace heights with the extent of protein degradation; higher terraces are older and have more degraded protein within their opercula. Only three individual opercula show non-closed system behaviour (2 from Purfleet and 1 from Sugworth [a Cromerian Complex site in the Upper Thames]), and these are easily identifiable from their non-concordance. After Penkman (2014).

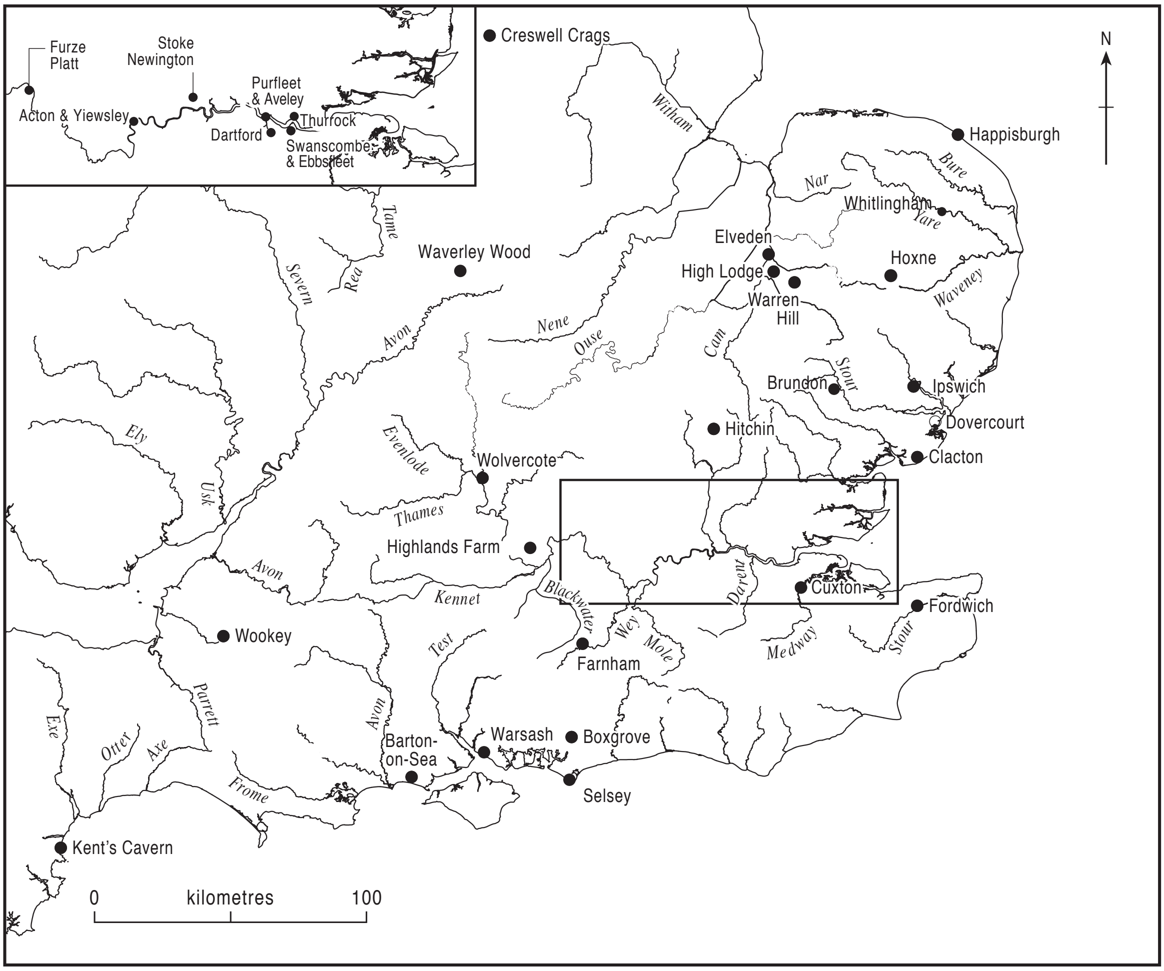
Figure 5: Summary of British Lower and Early Middle Palaeolithic archaeology, correlated with the marine isotope record, climate and sea-level (after White 2015)

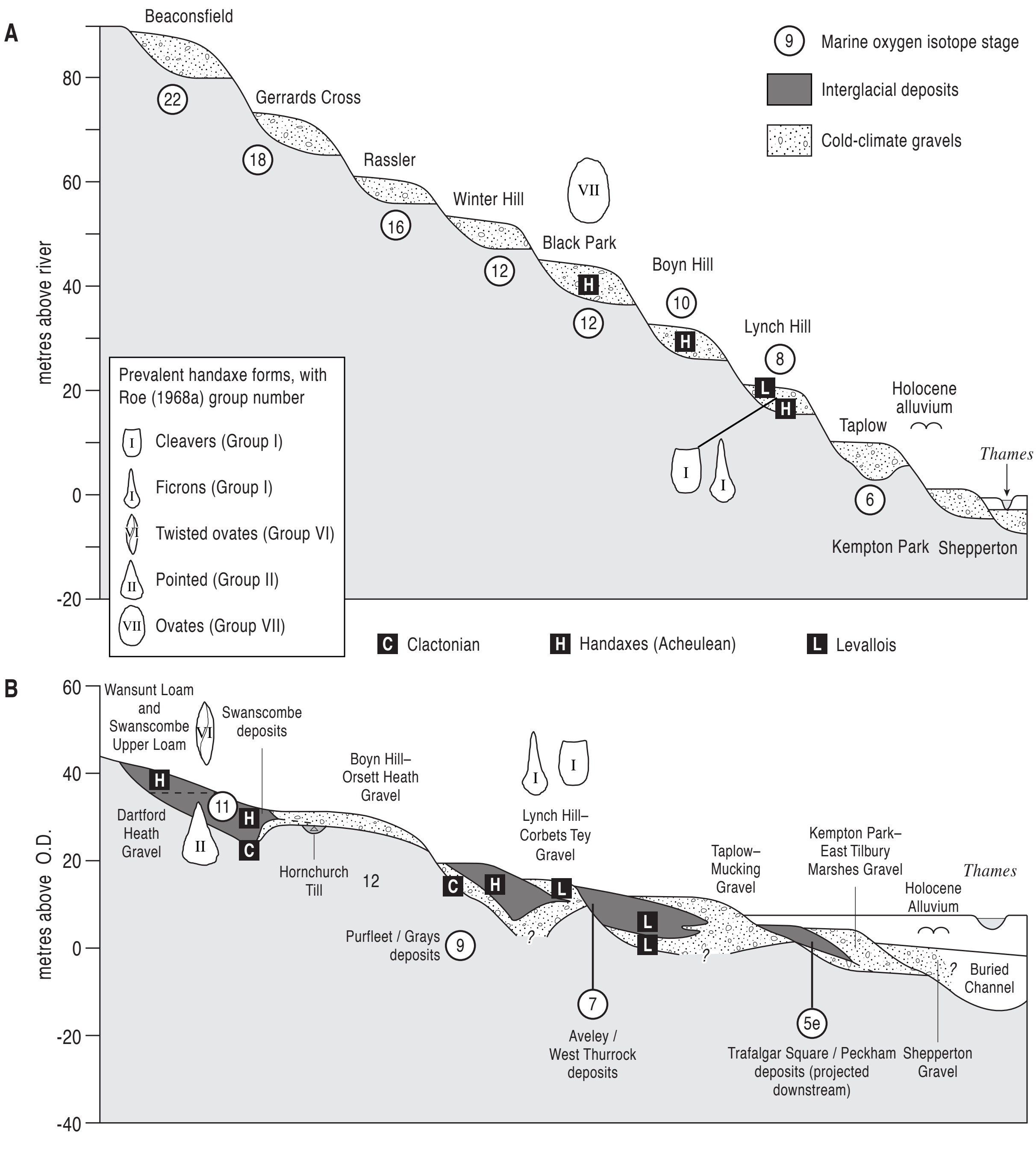
Figure 6: Lower Palaeolithic artefacts from the Thames Valley. A) Hard-hammer flake from the Lower Gravel at Greenland's Pit, Purfleet; b) Handaxe from the Middle Gravel at Blueland's Pit, Purfleet; c) Proto-Levallois core from Botany Pit, Purfleet; d) Lineal Levallois core from Botany Pit, Purfleet; e & f) a cleaver and a ficron from Furze Platt (after Wymer 1968); g) a twisted ovate handaxe from the Upper Loam, Barnfield Pit, Swanscombe (after Roe 1981)

TABLE CAPTIONS

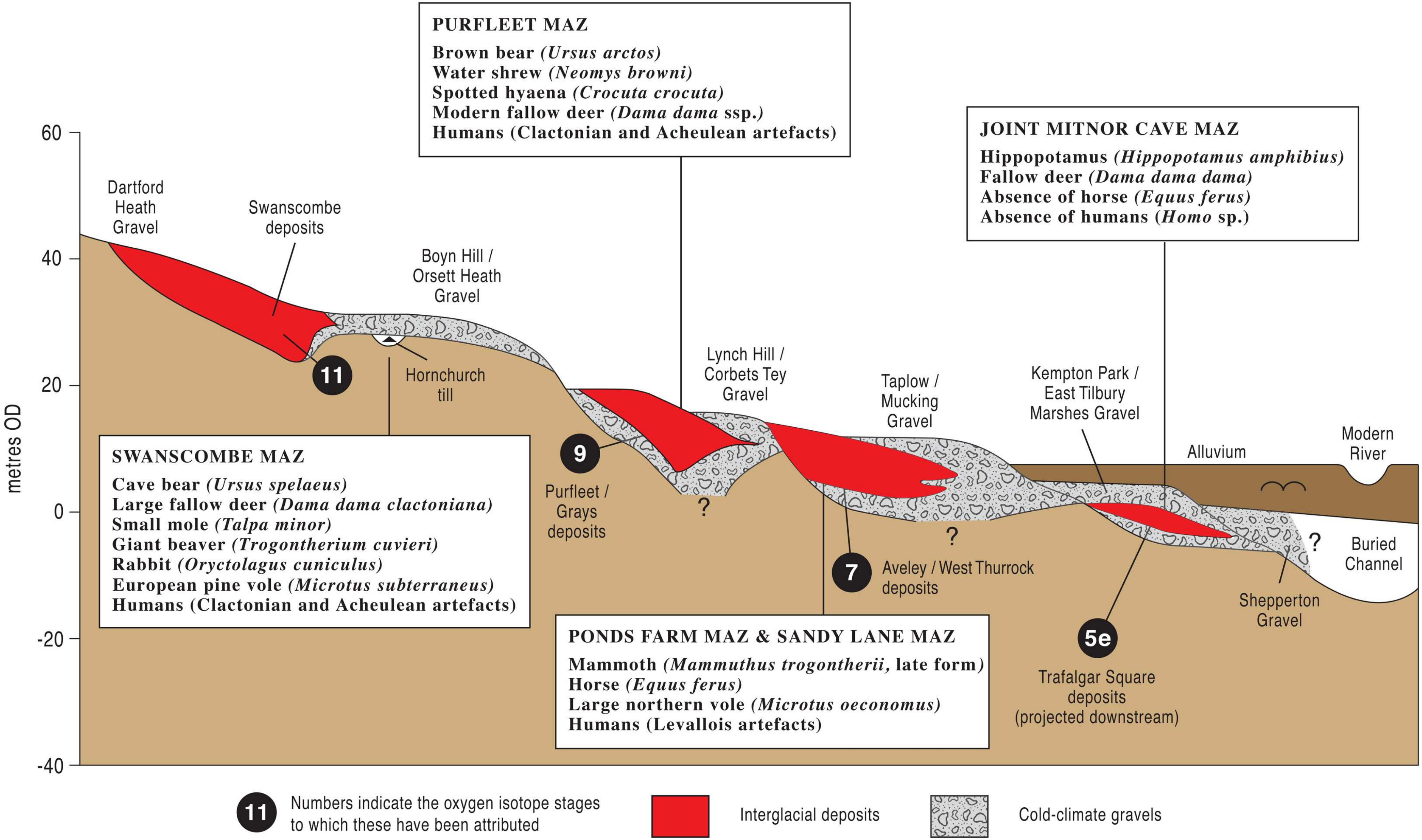
Table 1: British handaxe traditions according to Derek Roe (1968) with inferred ages after White 2015 & Bridgland and White 2014

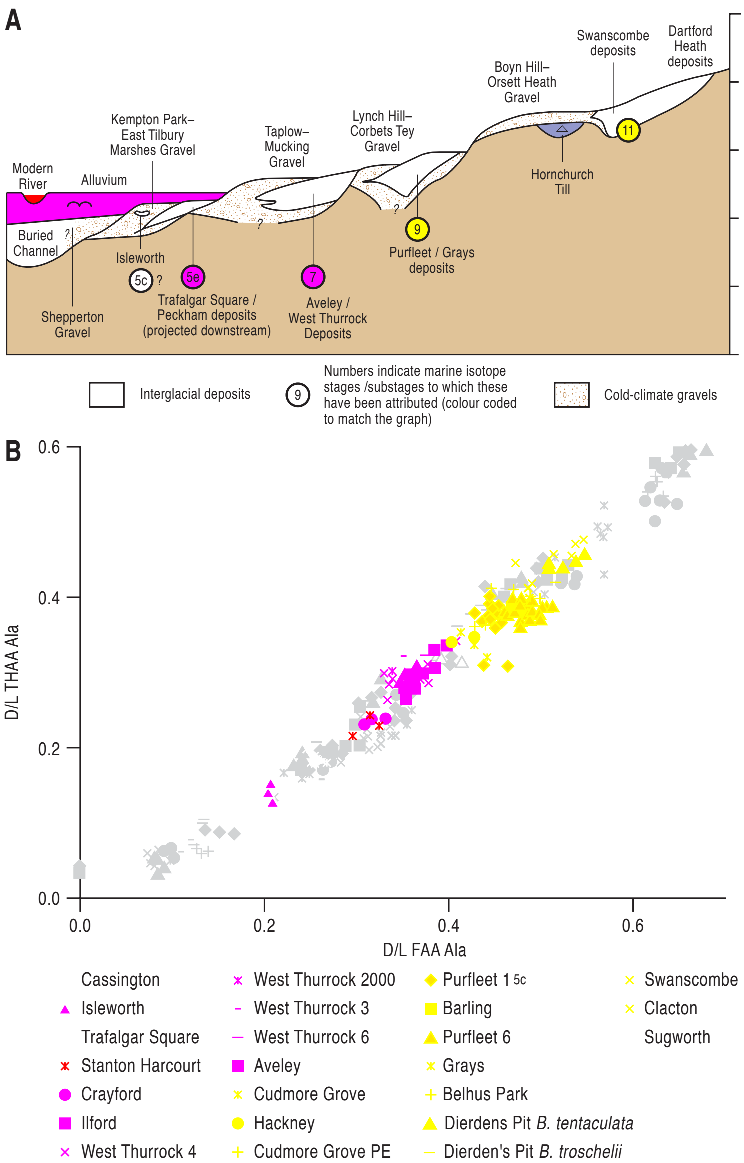
Table 2: Presence/absence data of selected biostratigraphically important mammals from British Middle and Late Pleistocene interglacial deposits, with their suggested Mammal Assemblage-Zone (MAZ) grouping, based on Schreve (2001a) and proposed correlation with the marine oxygen isotopic record. Data from [(1)]Roberts and Parfitt (1999); [(2)]Schreve (1996); [(3)]Schreve *et al.* (2002); [(4)]Schreve and Bridgland (2002); [(5)] Currant and Jacobi (2011).

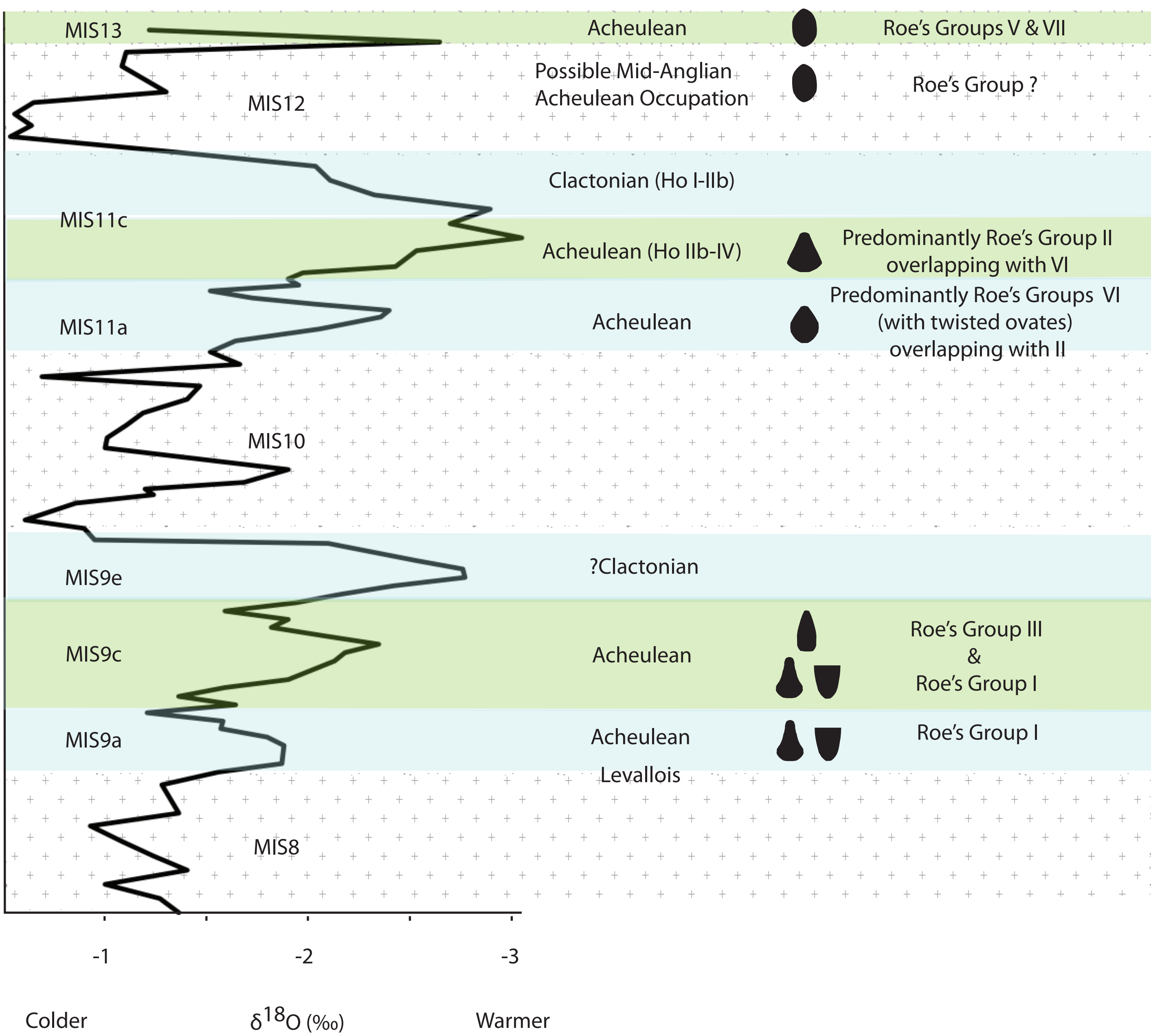

Furze
Platt
Stoke
Newington
Purfleet
& Aveley
Acton & Yiewsley
Thurrock
Dartford
Swanscombe
& Ebbsfleet
Creswell Crags
N
Witham
Happisburgh
Bure
Nar
Whitlingham
Yare
Tame
Elveden
Hoxne
Waverley Wood
High Lodge
Severn
Rea
Warren
Hill
Waveney
Nene
Avon
Ouse
Cam
Stour
Brundon
Ipswich
Dovercourt
Ely
Evenlode
Hitchin
Wolvercote
Clacton
Usk
Thames
Highlands Farm
Avon
Blackwater
Darent
Cuxton
Kennet
Fordwich
Wookey
Wey
Test
Mole
Medway
Stour
Farnham
Parrett
Exe
Avon
Otter
Axe
Barton-
on-Sea
Warsash
Boxgrove
Frome
Selsey
Kent's Cavern
0
kilometres
100

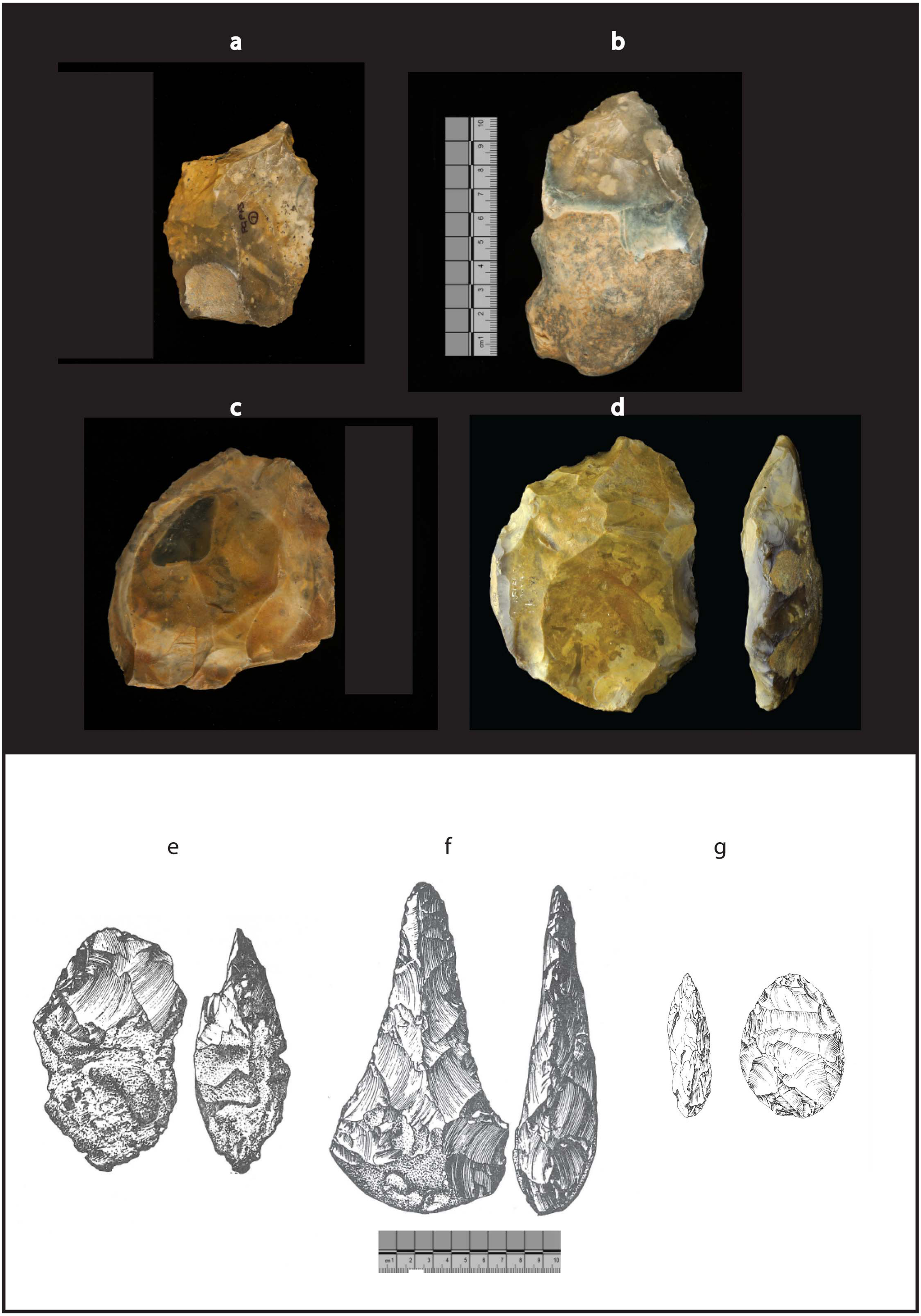


A
Beaconsfield
Gerrards Cross
Rassler
Winter Hill
Black Park
Boyn Hill
Lynch Hill
Taplow
Holocene alluvium
Thames
Kempton Park
Shepperton
22
18
16
12
12
10
8
6
VII
I
I
metres above river
80
60
40
20
0
-20
9 Marine oxygen isotope stage
Interglacial deposits
Cold-climate gravels
Prevalent handaxe forms, with Roe (1968a) group number
Cleavers (Group I)
Ficrons (Group I)
Twisted ovates (Group VI)
Pointed (Group II)
Ovates (Group VII)
C Clactonian
H Handaxes (Acheulean)
L Levallois
B
metres above O.D.
60
40
20
0
-20
-40
Wansunt Loam and Swanscombe Upper Loam
Swanscombe deposits
Boyn Hill–Orsett Heath Gravel
Dartford Heath Gravel
Hornchurch Till
12
11
Purfleet / Grays deposits
9
Lynch Hill–Corbets Tey Gravel
Taplow–Mucking Gravel
Kempton Park–East Tilbury Marshes Gravel
Thames
Holocene Alluvium
Buried Channel
7
Aveley / West Thurrock deposits
5e
Trafalgar Square / Peckham deposits (projected downstream)
Shepperton Gravel


PURFLEET MAZ
Brown bear (Ursus arctos)
Water shrew (Neomys browni)
Spotted hyaena (Crocuta crocuta)
Modern fallow deer (Dama dama ssp.)
Humans (Clactonian and Acheulean artefacts)
JOINT MITNOR CAVE MAZ
Hippopotamus (Hippopotamus amphibius)
Fallow deer (Dama dama dama)
Absence of horse (Equus ferus)
Absence of humans (Homo sp.)
60
40
20
0
-20
-40
metres OD
Dartford Heath Gravel
Swanscombe deposits
Boyn Hill / Orsett Heath Gravel
Hornchurch till
11
Lynch Hill / Corbets Tey Gravel
Taplow / Mucking Gravel
Kempton Park / East Tilbury Marshes Gravel
Alluvium
Modern River
9
Purfleet / Grays deposits
?
7
Aveley / West Thurrock deposits
Buried Channel
Shepperton Gravel
5e
Trafalgar Square deposits (projected downstream)
SWANSCOMBE MAZ
Cave bear (Ursus spelaeus)
Large fallow deer (Dama dama clactoniana)
Small mole (Talpa minor)
Giant beaver (Trogontherium cuvieri)
Rabbit (Oryctolagus cuniculus)
European pine vole (Microtus subterraneus)
Humans (Clactonian and Acheulean artefacts)
PONDS FARM MAZ & SANDY LANE MAZ
Mammoth (Mammuthus trogontherii, late form)
Horse (Equus ferus)
Large northern vole (Microtus oeconomus)
Humans (Levallois artefacts)
11 Numbers indicate the oxygen isotope stages to which these have been attributed
Interglacial deposits
Cold-climate gravels


A
Modern River
Alluvium
Kempton Park–East Tilbury Marshes Gravel
Taplow–Mucking Gravel
Lynch Hill–Corbets Tey Gravel
Boyn Hill–Orsett Heath Gravel
Swanscombe deposits
Dartford Heath deposits
Hornchurch Till
Buried Channel
Isleworth
5c
5e
7
9
11
Shepperton Gravel
Trafalgar Square / Peckham deposits (projected downstream)
Aveley / West Thurrock Deposits
Purfleet / Grays deposits
metres O.D.
60
40
20
0
-20
-40
Interglacial deposits
Numbers indicate marine isotope stages /substages to which these have been attributed (colour coded to match the graph)
Cold-climate gravels
B
D/L THAA Ala
D/L FAA Ala
0.0
0.2
0.4
0.6
Cassington
Isleworth
Trafalgar Square
Stanton Harcourt
Crayford
Ilford
West Thurrock 4
West Thurrock 2000
West Thurrock 3
West Thurrock 6
Aveley
Cudmore Grove
Hackney
Cudmore Grove PE
Purfleet 1 5c
Barling
Purfleet 6
Grays
Belhus Park
Dierdens Pit B. tentaculata
Dierden's Pit B. troschelii
Swanscombe
Clacton
Sugworth


MIS13
Acheulean
Roe's Groups V & VII
MIS12
Possible Mid-Anglian
Acheulean Occupation
Roe's Group ?
Clactonian (Ho I-IIb)
MIS11c
Acheulean (Ho IIb-IV)
Predominantly Roe's Group II
overlapping with VI
MIS11a
Acheulean
Predominantly Roe's Groups VI
(with twisted ovates)
overlapping with II
MIS10
MIS9e
?Clactonian
MIS9c
Acheulean
Roe's Group III
&
Roe's Group I
MIS9a
Acheulean
Roe's Group I
Levallois
MIS8
-1
-2
-3
Colder
δ18O (‰)
Warmer


a
b
c
d
e
f
g

← Pointed tradition →			← Ovate tradition →		
Group I (with cleavers)	Group II (with ovates)	Group III (plano-convex)	Group V (crude, narrow)	Group VI (more pointed)	Group VII (less pointed)
MIS 9–8	MIS 11	MIS 9	MIS 15–13	MIS 11	MIS 13
Furze Platt	Swanscombe MG	Wolvercote	Fordwich	Elveden	High Lodge
Bakers Farm	Chadwell St Mary		Farnham terrace A	Bowman's Lodge	Warren Hill fresh
Cuxton	(Hoxne UI)		Warren Hill worn	Swanscombe UL	Highlands Farm (Black Park Terrace)
Stoke Newington	Dovercourt		(Kents Cavern Breccia)	(Wansunt)	Corfe Mullen
	Hitchin		[Black Park Terrace (worn)]	(Foxhall Road Grey Clay)	(Boxgrove)
	(Foxhall Road Red Gravel)			(Hoxne LI)	
				MIS 13–12	
				Caversham	
				Middle Palaeolithic	
				Shide, Pan Farm	
				Oldbury	

Table 1. An update of Roe's (1968a) British handaxe groups, with inferred ages after White (2015). Additions by White are in parentheses. Additions for tis paper are in square brackets.

Suggested MIS correlation	13	11	9	7e	7a	5e
Site	**Boxgrove** [(1)]	**Swanscombe MAZ** [(2)]	**Purfleet MAZ** [(3)]	**Ponds Farm MAZ** [(4)]	**Sandy Lane MAZ** [(4)]	**Joint Mitnor Cave MAZ** [(5)]
Taxon						
Talpa minor	**X**	**X**				
Trogontherium cuvieri	**X**	**X**				
Ursus deningeri	**X**					
Stephanorhinus hundsheimensis	**LAB**					
Oryctolagus cuniculus	**X**	**LAB**				
Ursus spelaeus		**F&LAB**				
Dama dama clactoniana		**F&LAB**				
Microtus (*Terricola*) *subterraneus*		**LAB**				
Macaca sylvanus		**X**	**LAB**			
Stephanorhinus kirchbergensis		**FAB**	**X**		**X**	
Equus ferus	**X**	**X**	**X**	**X**	**X**	
Homo sp.	**X**	**X**	**X**	**X**	**X**	
Stephanorhinus hemitoechus		**FAB**	**X**		**X**	**X**
Ursus arctos			**FAB**		**X**	**X**
Dama dama dama			**FAB**			**X**
Crocuta crocuta	**X**		**X**		**X**	**X**
Mammuthus trogontherii (late morphotype)					**X**	
Coelodonta antiquitatis					**X**	
Hippopotamus amphibius						**X**

X = confirmed presence

FAB = first appearance in Britain
LAB = last appearance in Britain